STATE OF NEW YORK
PUBLIC SERVICE COMMISSION

CASE 16-E-0060 – Proceeding on Motion of the Commission as to the Rates, Charges, Rules and Regulations of Consolidated Edison Company of New York, Inc. for Electric Service.

2018 Outcome-Based EAM Collaborative Report

October 17, 2018

COLLABORATIVE PARTICIPANTS

Acadia Center, Association for Energy Affordability, Inc., City of New York, Consolidated Edison Company of New York, Inc., Consumer Power Advocates, E Cubed, Enel, Environmental Defense Fund, New York State Department of Public Service, New York Energy Consumers Council, New York Metropolitan Transportation Authority, Pace Energy and Climate Center, and Utility Intervention Unit

Table of Contents

1. Background

The Public Service Commission's ("Commission") *Order Approving Electric and Gas Rate Plans* ("Order") in this proceeding adopted program-achievement based and outcome-based earnings adjustment mechanisms ("EAMs") for Consolidated Edison Company of New York, Inc. ("Con Edison" or the "Company").[1] The EAM concept was introduced in the Reforming the Energy Vision ("REV") proceeding and formalized in the REV Track 2 Order.[2]

Program-achievement based EAMs are designed to incentivize the Company to deliver higher levels of energy and demand savings through its direct efforts implementing its energy efficiency and demand management programs. The programmatic EAMs incentivize incremental annual energy ("GWh") savings and incremental annual system peak demand ("MW") reductions.

Outcome-based EAMs seek to incentivize the Company to facilitate activities linked to desired outcomes within the entire Con Edison service territory regardless of whether such activities are solely or primarily the Company's own activities or whether such activities are carried out by other market actors, potentially with the Company's support or cooperation.[3]

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[1] Case 16-E-0060, *Proceeding on Motion of the Commission as to the Rates, Charges, Rules and Regulations of Consolidated Edison Company of New York, Inc. for Electric Service*, Order Approving Electric and Gas Rate Plans ("Order") (issued January 25, 2017).

[2] Case 14-M-0101, *Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision*, Order Adopting a Ratemaking and Utility Revenue Model Policy Framework (issued May 19, 2016) ("Track 2 Order").

[3] These EAMs seek to influence and measure outcomes based on metrics and incentivize the Company to facilitate achievement of targets associated with those metrics. The rate plan approved by the Commission broadly defined the goals and fixed the overall incentive amounts related to outcome-based EAMs and deferred the details to be worked out and developed through a collaborative process with interested parties ("the Collaborative"). The first Collaborative commenced in September 2016, and most of the Collaborative members filed *Comments Supporting Resolution of Outcome-based EAM Collaborative Issues* ("Collaborative Report") on November 2, 2016, with opposing parties filing separate comments. The Commission approved the Collaborative's recommendations in its *Order Approving Electric and Gas Rate Plans* on January 25, 2017, which established the EAMs and associated metrics, targets, and incentives for rate year ("RY") 1. The Collaborative parties met in person or by phone on several occasions from June through August 2017 and filed their consensus *2017 Outcome-based EAM Collaborative Report* on August 23, 2017, with metrics, targets, and incentive levels, for RY2 EAMs. During the 2017 outcome-based EAM discussions, some Collaborative parties expressed interest in developing an outcome-based Greenhouse Gas ("GHG") or carbon dioxide equivalent ("CO_2e") emissions reduction related metric for consideration in RY2 or RY3. The Collaborative parties developed the metric by meeting six times on an approximate monthly basis starting in September 2017 and filed their consensus *2017 Outcome-based EAM Collaborative Emissions Metric Report* and accompanying *Con Edison Emissions EAM Targeted Technologies Calculations* file on April 30, 2018. The Collaborative parties agreed that a targeted approach, focused on specific technologies and practices with beneficial emissions impacts, would form the basis of a primary emissions reduction-related outcome-based EAM metric for RY3 (and as a scorecard only in RY2) to encourage Company actions to reduce emissions. The targeted approach measures annualized avoided metric tons of CO_2e emissions from specific interventions in the Company's service territory.

2. Summary of 2018 Outcome-based EAM Collaborative

The Collaborative parties reconvened on June 8, 2018 to evaluate the outcome-based EAMs, met in person or by phone six times, and recommend the revised and updated metrics, targets, and incentive levels for RY3 EAMs summarized in this consensus document. Revisions and updates to the metrics and other details with regard to RY3 EAMs may include, but are not limited to, changes to the metrics including the relative weighting related to a metric or its associated incentives, appropriate incorporation of information from interim trends, analyses, and experience with implementation of the prior rate years' EAMs.[4]

Parties participating in all or some of the 2018 Collaborative meetings included Acadia Center, Association for Energy Affordability, Inc., City of New York, Con Edison, Consumer Power Advocates, E Cubed, Enel, Environmental Defense Fund, New York Energy Consumers Council, New York State Department of Public Service ("Staff"), New York Metropolitan Transportation Authority ("MTA"), and Utility Intervention Unit ("UIU").

Parties that have indicated their affirmative support for the proposal outlined in this document include Acadia Center, Association for Energy Affordability, Inc., City of New York, Con Edison, Consumer Power Advocates, E Cubed, Enel, Environmental Defense Fund, MTA, and Staff. Parties that do not support this proposal in its entirety include New York Energy Consumers Council and UIU.[5] No parties oppose the proposal in its entirety.

3. Outcome-based EAMs

A. DER Utilization

i. Discussion

The Order broadly defines the DER Utilization EAM as:

> DER Utilization – this EAM is intended to encourage Con Edison to work with DER providers and expand the use of DER in its service territory both for the purposes of reducing customer reliance on grid-supplied electricity and for beneficial electrification.[6]

For the purpose of RY3, DERs are defined in Table 1 below:

[4] The Track 2 Order stated on pp. 70-71 "EAMs will be evaluated for their effectiveness with opportunities to revise EAMs and to retire or introduce new EAMs based on future system needs." The Commission has not yet issued an Order regarding the previously proposed RY2 EAMs from this Collaborative. In addition, the Company is still waiting on certain 2017 data from the federal government before it can determine whether or not the 2017 Commercial Energy Intensity metric has met the targets set in RY1 and whether any EAM has been earned for that metric for RY1.

[5] UIU opposes any incentives for increasing air-sourced heat pump installations without analysis to understand the potential costs, and the estimated timing of those costs, that widespread adoption of heat pumps may bring to the electric distribution and transmission systems.

[6] Order, Appendix A - Joint Proposal, p. 78.

Table 1: **DER Utilization technologies**[7]

<table>
<tr><th>Reducing customer reliance on grid-supplied electricity</th><th>Beneficial electrification</th></tr>
<tr><td>Solar photovoltaics (PV)</td><td>Ice energy storage</td></tr>
<tr><td>Combined heat and power (CHP)</td><td>Light-duty EV charging</td></tr>
<tr><td>Fuel cells</td><td>Electric Bus charging</td></tr>
<tr><td>Demand response (DR)</td><td></td></tr>
<tr><td colspan="2">Battery storage</td></tr>
<tr><td colspan="2">Heat pumps</td></tr>
</table>

DERs will be measured in terms of their rated capacity, except for demand response ("DR") for which the number of DR events and actual performance will be used. To standardize across technologies, all measurements will be in annualized megawatt-hours ("MWh") using the formulae described in this section. For each DER type, Con Edison will determine MWh produced, consumed, discharged, or reduced from incremental[8] resources as follows:

DER Utilization (MWh) = Rooftop Solar PV MWh annualized production
+ Community Solar PV MWh annualized production
+ Combined heat and power ("CHP") MWh annualized production
+ Fuel cell MWh annualized production
+ Battery storage MWh annualized discharge
+ Demand response MWh annualized reduction
+ Ice energy storage MWh annualized consumption
+ Battery storage MWh annualized charging
+ Light-Duty Electric Vehicle MWh annualized charging
+ Electric Bus MWh annualized charging
+ Air-Source and Ground-Source Heat Pump MWh annualized reduction & consumption

MWh are treated as positive values with the sum of produced, consumed, and reduced (in the case of DR and heat pump efficiency), energy determining achievement against a target; that is, 1 MWh produced is equivalent to 1 MWh consumed (or 1 MWh reduced in the case of DR and heat pump efficiency) for the purpose of the metric.

[7] Battery storage and heat pumps have the characteristic of being both a DER reducing customer reliance on grid-supplied electricity, and a DER with beneficial electrification. Battery storage charges off peak, typically from low greenhouse gas emitting sources, which is a beneficial electrification (consumption). Battery storage discharges on peak, reducing customer reliance on the grid. Additionally, battery storage often provides resiliency benefits. Heat pumps provide efficient cooling during the summer and can partially or fully replace fossil fuel fired heating in the winter (beneficial electrification).

[8] For each technology categorized as a DER under the DER Utilization EAM metric, incremental resources, for the purposes of determining achievement under this EAM, are defined as all DERs belonging to the respective technology that becomes electrically connected to the Con Edison delivery system during the rate year.

Because not all DERs are individually metered or measured, MWh produced or consumed by incremental DERs will be determined on an annualized basis using the formulae and assumptions described below.

ii. Measurement

Reductions in Customer Load

Rooftop Solar Photovoltaics

The rooftop solar photovoltaics ("PV")[9] measurement will include all incremental rooftop solar PV installations as summed at the end of the rate year (December 31, 2019). End-of-year incremental installed capacity will be tracked from interconnected rooftop solar PV submitted through the New York State Standardized Interconnection Requirements ("NYS SIR") process.[10] The Company will count these rooftop solar PV installations toward the DER Utilization metric when it has submitted a final interconnection letter to the customer noting that all interconnection work has been completed, which enables the rooftop solar installation to begin operating as part of the overall Con Edison delivery system.

Annualized MWh from rooftop solar PV installations[11] will be calculated as:

[Megawatts Solar PV] * [8760 hours per year] * [14.1% annual capacity factor]

Community Solar Photovoltaics

The community solar PV measurement will include all incremental community solar PV installations as summed at the end of RY3. End-of-year incremental installed capacity will be tracked from interconnected community solar PV submitted through the NYS SIR process. The Company will count those community solar PV installations toward the DER Utilization metric when the Company submits a final interconnection letter to the customer noting that all interconnection work has been completed, which enables the community solar installation to begin operating as part of the overall Con Edison delivery system.

Annualized MWh from community solar PV installations[12] will be calculated as:

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[9] As used herein, "rooftop solar PV installations" include pad- and pedestal-mounted solar PV installations.

[10] The customer is allowed to commence parallel operation of its DER upon satisfactory completion of witness testing (a step in the SIR), which occurs prior to the Company issuing the final interconnection letter. The Company is physically present at the DER site for all CHP, battery, fuel cell, and solar (>50kW) witness tests, as part of the SIR process. The DER systems are operating during this test and if the DER fails the verification/witness test, the Company revisits the DER site after issues have been resolved. A final interconnection letter is only issued after successful completion of the test.

[11] Case 15-E-0751, In the Matter of the Value of Distributed Energy Resources, *Copy of Solar Simulations for DPS* (October 28, 2016).

[12] Case 15-E-0751, In the Matter of the Value of Distributed Energy Resources, *Copy of Solar Simulations for DPS* (October 28, 2016).

[Megawatts Solar PV] * [8760 hours per year] * [15.5% annual capacity factor]

Combined Heat and Power

The Combined Heat and Power ("CHP") measurement will include all incremental CHP installations as summed at the end of the rate year.[13] For installations less than or equal to 5 MW nameplate capacity, installation specifications will be obtained from the NYS SIR process. For installations greater than 5 MW nameplate capacity, installation specifications will be obtained from the Con Edison Large Distributed Generation ("DG") Interconnection process. The Company will count those CHP installations toward the DER Utilization metric when the Company submits a final interconnection letter to the customer noting that all interconnection work has been completed, which enables the CHP installation to begin operating as part of the overall Con Edison delivery system.

Annualized MWh from CHP installations will be calculated by multiplying CHP installation nameplate capacity by 8,760 hours and a capacity factor of 75 percent.[14]

Fuel Cells

The fuel cell measurement will include all incremental fuel cell installations as summed at the end of the rate year. For installations less than or equal to 5 MW nameplate capacity, installation specifications will be obtained from the NYS SIR process. For installations greater than 5 MW nameplate capacity, installation specifications will be obtained from the Con Edison Large DG Interconnection process. The Company will count those fuel cell installations toward the DER Utilization metric when the Company submits a final interconnection letter to the customer noting that all interconnection work has been completed, which enables the fuel cell installation to begin operating as part of the overall Con Edison delivery system.

Annualized MWh from fuel cells will be calculated by multiplying fuel cell installation nameplate capacity by 8,760 hours and a capacity factor of 91 percent.[15]

Batteries

The batteries measurement will include all incremental battery installations as summed at the end of the rate year. End-of-year incremental installed capacity will be tracked from interconnected battery storage submitted through the NYS SIR process. The Company will count those battery installations toward the DER Utilization metric when the Company submits a final interconnection letter to the customer noting that all interconnection work has been completed, which enables the battery installation to begin operating as part of the overall Con Edison delivery system.

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[13] A very large CHP project is expected to come online in RY3 that would translate to a level of MWh representing more than 100 percent of the maximum target selected for DER Utilization. This project will not be considered for the RY3 DER Utilization metric, but will be noted in the Company's RY3 EAMs achievements report if it interconnects to the Con Edison delivery system in RY3.

[14] NYSERDA Distributed Generation-Combined Heat and Power Impact Evaluation, March 2015, p. 12.

[15] *Id.* p. 12.

Annualized MWh discharged (produced) by batteries will be calculated as:

[Battery inverter discharge rating (MWh)] * [365 days per year][16]

Demand Response

The DR MWh measurement will consider all incremental entrants into the Con Edison Commercial System Relief Program and Distribution Load Relief Program, and New York State Independent System Operator ("NYISO") Special Case Resources ("SCR") DR program during RY3. Con Edison is able to determine the actual MWh attributable to its DR programs and most MWh attributable to the NYISO SCR program.[17] For any NYISO SCR program MWh not tracked by the Company, new entrant performance data will be retrieved from NYISO at the end of the rate year as NYISO DR participants submit data to the NYISO at year-end for settlement. For the purposes of measuring MWh for inclusion in the DER Utilization metric, the Company will multiply incremental new MW in each applicable DR program by (i) the total annual program event duration, in hours, during the rate year and (ii) the average annual performance, in percent, of all DR participants in that program. A sum of all load relief, in MWh, from all the DR programs will then be included in the DER Utilization metric.

Heat Pumps

The heat pump measurement will consider all incremental air-source heat pumps ("ASHP") and ground-source heat pumps ("GSHP") installations as summed at the end of RY3. End-of-year incremental installed units will be tracked through Company activity and NYSERDA reported installations.

Annualized MWh saved by ASHP and GSHP will be calculated as:

$$(ASHP\ Installs)\ X\left(\frac{0.422\ MWh}{Unit}\right)+\ (GSHP\ Installs)\ X\left(\frac{1.096\ MWh}{Unit}\right)$$

For the purposes of this EAM metric, it is assumed that 80 percent of heat pumps replace a window air conditioning ("AC") unit, and 20 percent of heat pumps replace central air conditioning for the cooling season.[18]

Beneficial Electrification

Batteries

The batteries beneficial electrification measurement will include all incremental battery installations as summed at the end of RY3. End-of-year incremental installed capacity will be tracked from interconnected battery storage submitted through the NYS SIR process. The Company will count those

[16] Refer to Appendix B, Page B-12 of DOE/EPRI Electricity Storage Handbook

[17] Some NYISO SCR program participants do not have billing interval meters, thereby requiring the Company to estimate the MWh attributable to such participants' participation in that program.

[18] The cooling and heating replacement scenarios are based on the U.S. Census Bureau's 2015 American Housing Survey data for New York City, which may not include data from Westchester County and may include data from Newark and Jersey City, New Jersey, but is generally representative of installations in Company territory.

battery installations toward the DER Utilization metric when the Company submits a final interconnection letter to the customer noting that all interconnection work has been completed, which enables the battery installation to begin operating as part of the overall Con Edison delivery system.

Annualized MWh consumed by batteries will be calculated as:

[Daily battery inverter discharge rating (MWh)] * [365 days per year] / [83% round trip efficiency]

Ice Energy Storage

The ice energy storage beneficial electrification measurement will consider all incremental ice energy storage (i.e., excluding chillers that do not utilize storage to shift load) as summed at the end of the rate year. Project specifications will be collected through the Company's Incremental System Peak MW Reduction and Non-Wires Solutions ("NWS") programs, including the 2019 Demand Management Program. If a project is installed outside of the Incremental System Peak MW Reduction programs, the Company will request the required information from the companies or customers involved.

The Company will utilize each installation's specifications to determine tonnage capacity, hours per charge, and total annualized charges. The Company will then apply a 0.55 kW per ton factor to reach total MWh attributable to thermal energy storage.

$$(Installs)\ \mathrm{X} \left(\frac{0.55kW}{ton}\right)\ X\ \left(\frac{tons}{install}\right) X\ \left(\frac{hours}{charge}\right) X\ (total\ annualized\ charges)$$

Heat Pumps

The heat pump beneficial electrification measurement will consider all incremental air-source heat pumps ("ASHP") and ground-source heat pumps ("GSHP") installations as summed at the end of the rate year. End-of-year incremental installed units will be tracked through Company activity and NYSERDA reported installations.

Annualized MWh saved by ASHP and GSHP will be calculated as:

$$(ASHP\ Installs)\ X \left(\frac{0.734\ MWh}{Unit}\right) + \ (GSHP\ Installs)\ X \left(\frac{2.380\ MWh}{Unit}\right)$$

For the purposes of this EAM metric, it is assumed that each heat pump replaces its equivalent amount of heating load as from a natural gas or fuel oil fired furnace. Also, for the purposes of this EAM metric calculation, 70 percent of heat pump installations will replace its equivalent amount of heating load from a natural gas fired furnace, and 30 percent of heat pump installations will replace its equivalent amount of heating load from a fuel oil fired furnace.

Light-Duty Electric Vehicles

The light-duty EV beneficial electrification measurement will consider incremental Plug-In Electric Vehicle ("PHEV") and Battery Electric Vehicle ("BEV") registrations in the Company's service territory as summed at the end of RY3. The Company tracks registrations in its service territory provided to it by

NYSERDA which receives information from the New York State Department of Motor Vehicles.[19] The MWh associated with EVs is calculated by multiplying the registered number of BEVs and PHEVs by their average daily energy consumption,[20] as shown below:

$$(\#\ of\ \boldsymbol{BEVs})\ X\ \left(\frac{10.33kWh}{weekday}\right) X\ \left(\frac{weekdays}{year}\right) + (\#\ of\ \boldsymbol{PHEVs})\ X\ \left(\frac{7.0kWh}{weekday}\right) X\ \left(\frac{weekdays}{year}\right)$$

Electric Buses

The electric bus beneficial electrification measurement will consider incremental electric bus registrations in the Company's service territory as summed at the end of RY3. The Company tracks registrations in its service territory provided to it by the MTA. The MWh associated with electric buses is calculated by multiplying the registered number of electric buses by their average daily energy consumption,[21] as shown below:

$$(\#\ of\ Electric\ Buses)\ X\ \left(\frac{72.89kWh}{day}\right) X\ \left(\frac{days}{year}\right)$$

Regenerative Braking and Energy Storage

During the Collaborative, the MTA expressed interest in developing a measurement for regenerative braking combined with energy storage and discharge on its subway and other train cars. The MTA is working, and will continue to work in RY3, with Con Edison to implement and quantify the electric system benefits of regenerative braking combined with energy storage. To the extent the MTA and Con Edison are able to measure and confidently quantify electric system benefits of regenerative braking combined with energy storage and discharge on subway and other train cars in the service territory, this information will be used to inform consideration of inclusion in a future metric.

B. Greenhouse Gas Emissions Reduction Metric and Scorecard

i. Targeted Approach Discussion

The targeted approach addresses annualized avoided metric tons CO_2e from rooftop and community solar PV, light-duty EVs, electric buses, ASHP, GSHP, battery storage, ice energy storage, electric water heaters, wind energy, and voluntary renewable energy certificates ("VREC"). These technologies, or market activity in the case of VRECs, were selected due to their beneficial emissions impacts.[22]

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[19] The Company intends to use EValuateNY, a new NYSERDA-funded tool, to track BEV and PHEV registrations in its service territory.

[20] The average consumption for BEVs and PHEVs is based on the NYSERDA-funded study, *Electricity Pricing Strategies to Reduce Grid Impacts from Plug-in Electric Vehicle Charging in New York State*.

[21] The average daily consumption for electric buses is based on approximately six months of electric bus data provided by the MTA, from 10 electric buses. The Company will work with the MTA to update average daily electric bus energy consumption in future rate years, as more electric bus data become available.

[22] Broad energy efficiency has significant beneficial emissions impacts, but was not selected for the Emissions Reduction EAM metric because it is already directly or indirectly supported through the Company's programmatic or existing outcome-based EAMs.

ii. Targeted Approach Measurement

To standardize measurement across technologies, all measurements for the targeted approach will be in annualized avoided metric tons CO_2e using the formulae described in this section. For each DER type, Con Edison will determine annualized avoided metric tons CO_2e from incremental[23] resources as follows:

Total Avoided Emissions = Rooftop Solar PV annualized avoided metric tons CO_2e
+ Community Solar PV annualized avoided metric tons CO_2e
+ Light-Duty Battery Electric Vehicle annualized avoided metric tons CO_2e
+ Electric Bus annualized avoided metric tons CO_2e
+ Heat Pump (ASHP and GSHP) annualized avoided metric tons CO_2e
+ Battery storage annualized avoided metric tons CO_2e
+ Ice energy storage annualized avoided metric tons CO_2e
+ Electric heat pump water heater annualized avoided metric tons CO_2e
+ Wind energy annualized avoided metric tons CO_2e
+ Voluntary REC annualized avoided metric tons CO_2e

Metric tons CO_2e are treated as positive values with the sum of avoided kg CO_2e emissions, converted after initial calculation to metric tons CO_2e emissions, determining achievement. The avoided emissions measurements use electricity emissions factors of Grid kg CO_2e per Megawatt-hour ("MWh") and/or Peak kg CO_2e per MWh, and other technology-specific factors, to determine annualized avoided metric tons CO_2e. For the purposes of the Emissions Reduction EAM, the Grid kg CO_2e value is the 2016 New York City electricity emissions factor from the 2018 New York City GHG Inventory.[24] The Peak kg CO_2e per MWh value is sourced from the Environmental Protection Agency's ("EPA") Emissions & Generation Resource Integrated Database ("eGRID") for the Northeast Power Coordinating Council ("NPCC") NYC/Westchester subregion.[25]

Because not all DERs are individually metered or measured, annualized metric tons CO_2e emissions avoided from incremental DERs will be determined using the formulae and assumptions described below. Additional measurement details can be found in Appendix B.

Rooftop Solar Photovoltaics

The rooftop solar PV[26] measurement will include all incremental rooftop solar PV installations as summed at the end of RY3. End-of-year incremental installed capacity will be tracked from interconnected rooftop solar PV submitted through the NYS SIR process. The Company will count these rooftop solar PV installations toward the Emissions Reduction EAM metric when it submits a final interconnection letter to the customer noting that all interconnection work has been completed, which

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[23] For each DER technology in the Emissions Reduction EAM for which interconnection to the Company's electric delivery system is required, incremental resources, for the purposes of determining achievement under this EAM, are defined as all DERs belonging to the respective technology that becomes electrically connected to the Con Edison delivery system during the rate year.

[24] Inventory of New York City Greenhouse Gas Emissions in 2016, page 15.

[25] https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid

[26] As used herein, "rooftop solar PV installations" include pad- and pedestal-mounted solar PV installations.

enables the rooftop solar installation to begin operating as part of the overall Con Edison delivery system.

Each PV installation reduces GHG emissions by avoiding energy (MWh) that would have been generated and supplied by the wholesale markets. The Company's service territory is supplied by a mix of generation sources including those with GHG emissions. Every MWh generated by the PV system can thus be assumed to displace an equivalent amount of wholesale generation, consequently avoiding GHG emissions. Annualized avoided metric tons CO_2e emissions from rooftop solar PV[27] installations will be determined by calculating the annual output of the PV system in MWh and multiplying by the average emission intensity of wholesale supply.

$$(MW\ solar\ PV) * (14.1\%\ Capacity\ factor) * (Annual\ Hours) * \left(\frac{Grid\ kg\ CO_2e}{MWh}\right)$$

Where:

MW solar PV	The MWs of solar PV installed and that can be expected to have begun operations in the Company's service territory in the rate year
Annual Hours	8,760
Grid kg CO_2e / MWh	The average New York City emissions factor from the most recent New York City GHG Inventory available at the time the EAM metric targets are determined

Community Solar Photovoltaics

The community solar PV measurement will include all incremental community solar PV installations as summed at the end of RY3. End-of-year incremental installed capacity will be tracked from interconnected community solar PV submitted through the NYS SIR process. The Company will count those community solar PV installations toward the Emissions Reduction EAM metric when the Company submits a final interconnection letter to the customer noting that all interconnection work has been completed, which enables the community solar installation to begin operating as part of the overall Con Edison delivery system.

The methodology for the community solar PV avoided metric tons CO_2e emissions calculation is the same as the rooftop solar PV calculation except for a higher capacity factor. Annualized avoided kg CO_2e emissions from community solar PV[28] installations will be calculated as:

$$(MW\ solar\ PV) * (15.5\%\ Capacity\ factor) * (Annual\ Hours) * \left(\frac{Grid\ kg\ CO_2e}{MWh}\right)$$

Where:

[27] Case 15-E-0751, *In the Matter of the Value of Distributed Energy Resources*, Copy of Solar Simulations for DPS (October 28, 2016).
[28] *Id.*

MW solar PV	The MWs of solar PV installed and that can be expected to have begun operations in the Company's service territory in the rate year
Annual Hours	8,760
Grid kg CO_2e / MWh	The average New York City emissions factor from the most recent New York City GHG Inventory available at the time the EAM metric targets are determined

Light-Duty Battery Electric Vehicles

The light-duty BEV measurement will consider incremental BEV registrations in the Company's service territory in RY3. The Company tracks registrations in its service territory provided to it by NYSERDA, which receives information from the New York State Department of Motor Vehicles.[29]

Electric vehicles reduce GHG emissions because GHG emissions associated with the electricity used by light-duty BEVs for New York City and Westchester are lower than GHG emissions resulting from a gasoline-based internal combustion engine. The generalized formula below calculates the net avoided GHG emissions from replacing an internal combustion engine vehicle with a BEV.[30]

$$(EVs) * \left(\frac{Annual\ MWh}{EV}\right) * \left(\frac{mile}{MWh}\right) * \left(\frac{kg\ CO2e}{mile_{ICE\ Vehicle}} - \frac{kg\ CO2e}{mile_{EV}}\right)$$

Where:

EVs	The number of BEVs registered in the Company's service territory in the rate year
Annual MWh / EV	The annual MWh consumed by a BEV at charging locations, based on assumptions identified in Appendix B
Mile / MWh	The average number of miles associated with one MWh of BEV discharge
kg CO_2e / $Mile_{ICE\ Vehicle}$	The emissions associated with one mile travelled in an internal combustion engine vehicle
kg CO_2e / $Mile_{EV}$	The emissions associated with one mile travelled in a BEV, using the average New York City emissions factor from the most recent New York

[29] The Company intends to use EValuateNY, a new NYSERDA-funded tool, to track BEV registrations in its service territory.

[30] Some Emissions Reduction EAM formulas in this report are generalized for ease of explanation. All detailed Emissions Reduction EAM calculations can be found in the Excel file and written calculations referenced in Appendix B.

City GHG Inventory available at the time the EAM metric targets are determined

Electric Buses

The electric bus measurement will consider incremental electric bus registrations in the Company's service territory in RY3. The Company tracks registrations in its service territory provided to it by the MTA.

Electric buses reduce GHG emissions because GHG emissions associated with the electricity used by electric buses for New York City and Westchester are lower than GHG emissions resulting from a diesel fuel-based internal combustion engine. The formula below calculates the net avoided metric tons CO_2e emissions from replacing a diesel bus with an electric bus.

$$(Electric\ Buses\ ) * \left(\frac{Annual\ MWh}{Electric\ Bus}\right) * \left(\frac{mile}{MWh}\right) * \left(\frac{kg\ CO2e}{mile_{Diesel\ Bus}} - \frac{kg\ CO2e}{mile_{Electric\ Bus}}\right)$$

Where:

Electric Buses	The number of electric buses registered in the Company's service territory in RY3
Annual MWh / EV	The annual MWh consumed by an electric buses at charging locations, based on assumptions identified in Appendix B
Mile / MWh	The average number of miles associated with one MWh of electric bus discharge
kg CO_2e / $Mile_{Diesel\ Bus}$	The emissions associated with one mile travelled in a diesel internal combustion engine bus
kg CO_2e / $Mile_{Electric\ Bus}$	The emissions associated with one mile travelled in an electric bus, using the average New York City emissions factor from the most recent New York City GHG Inventory available at the time the EAM metric targets are determined

Heat Pumps

The heat pump measurement will consider all incremental air-source heat pumps ("ASHP") and ground-source heat pumps ("GSHP") installations as summed at the end of RY3. End-of-year incremental installed units will be tracked through Company activity and NYSERDA reported installations.

Emissions benefits related to heat pump installations depend on the existing heating and cooling technology they are replacing or the heating and cooling technologies that would have otherwise been installed. However, for the purposes of the EAM, the Collaborative has developed a single framework for calculating avoided GHG emissions associated with heat pumps, which can be expected to be representative of heat pump installations in Company territory.

The annualized avoided metric tons of CO_2e emissions from ASHP and GSHP installations will be determined by calculating the net cooling and heating emissions impact. The ASHP and GSHP calculations will be conducted separately using the below generalized formula, but with varying input values (see Appendix B). The net cooling emissions impact calculates the avoided MWhs of consumption and applies the average grid emission intensity to determine the kg CO_2e avoided. The net heating emissions impact calculates the avoided emissions from replacing a natural gas or fuel oil fired heating system while accounting for the increased emissions associated with the increased electricity consumption by the heat pump.

$$(Heat\ Pump\ Units) * \begin{bmatrix} \left(\frac{MWh\ Cooling\ Avoided}{Unit\ Heat\ Pump} * \frac{Grid\ kg\ CO_2e}{MWh}\right) \\ + \left(Avoided\ Dth * \frac{kg\ CO_2e}{Dth}\right) \\ + \left(Avoided\ gallons * \frac{kg\ CO_2e}{gallon}\right) \\ - \left(\frac{MWh\ Heating\ Consumed}{Unit\ Heat\ Pump} * \frac{Grid\ kg\ CO_2e}{MWh}\right) \end{bmatrix}$$

Where:

Heat Pump Units	The number of heat pumps (ASHPs and GSHPs) installed in the Company's service territory in the rate year
MWh Cooling Avoided	The reduction in MWh consumed for cooling due to switching to an ASHP or GSHP from a less efficient air-conditioning system
Avoided Dekatherms ("Dth")	The reduction in Dth of natural gas consumed for heating due to switching to an ASHP or GSHP from a natural gas fired heating system
Avoided gallons	The reduction in gallons of fuel oil consumed for heating due to switching to an ASHP or GSHP from a fuel oil fired heating system
kg CO_2e / Dth	The emission intensity of burning natural gas (Dth)
kg CO2e / gallon	The emission intensity of burning fuel oil (gallons)
Grid kg CO_2e / MWh	The average New York City emissions factor from the most recent New York City GHG Inventory available at the time the EAM metric targets are determined
MWh Heating Consumed	The increase in electric consumption for heating due to replacing a natural gas fired heating system with an ASHP or GSHP

For the purposes of this EAM metric, it is assumed that 80 percent of heat pumps replace a window AC unit, and 20 percent of heat pumps replace central AC for the cooling season.[31] For the heating season, each heat pump replaces its equivalent amount of heating load as from a natural gas or fuel oil fired furnace. Also, for the purposes of this EAM metric calculation, 70 percent of heat pump installations will replace its equivalent amount of heating load from a natural gas fired furnace, and 30 percent of heat pump installations will replace its equivalent amount of heating load from a fuel oil fired furnace.

Battery Storage

The battery storage measurement will include all incremental battery installations as summed at the end of RY3. End-of-year incremental installed capacity will be tracked from interconnected battery storage submitted through the NYS SIR process. The Company will count those battery installations toward the Emissions Reduction EAM when the Company submits a final interconnection letter to the customer noting that all interconnection work has been completed, which enables the battery installation to begin operating as part of the overall Con Edison delivery system.

Battery storage systems are generally used to reduce a facility's electric demand during peak usage times. As a result, battery storage systems avoid GHG emissions by discharging when the emissions intensity of the grid is higher and charging during times when grid emissions are lower. The methodology below calculates the avoided emissions from discharging the battery at peak times and subtracts the emissions associated with charging the battery. The emissions associated with charging are adjusted by the round-trip efficiency of the battery because some electricity is lost in the storage-to-discharge cycle of the battery storage system.

$$(MW\ inverter\ rating) * \left[\left((Discharge\ time\ per\ day) * (365\ days\ per\ year) * \left(\frac{Peak\ kgCO_2e}{MWh}\right)\right) - \left(\frac{(Charge\ time\ \ per\ day) * (365\ days\ per\ year) * \left({}^{Grid\ kgCO_2e}/_{MWh}\right)}{83\%\ Round\ Trip\ Efficiency}\right)\right]$$

Where:

MW inverter rating	The MWs of capacity of the battery storage system, at the inverter
Discharge time per day	The hours per day a battery storage system discharges[32]
Charge time per day	The hours per day a battery storage system charges
Peak kg CO_2e / MWh	The emission intensity associated with peak electric demand from the EPA eGRID for the NPCC NYC/Westchester subregion

[31] The cooling and heating replacement scenarios are based on the U.S. Census Bureau's 2015 American Housing Survey data for New York City, which may not include data from Westchester County and may include data from Newark and Jersey City, New Jersey, but is generally representative of installations in Company territory.

[32] The Company will work to refine battery charge and discharge characteristics through battery projects in its service territory for which data is available.

Grid kg CO_2e / MWh	The average New York City emissions factor from the most recent New York City GHG Inventory available at the time the EAM metric targets are determined
Round Trip Efficiency	The efficiency of a battery storage system reproducing the electricity it consumed during charging

Ice Energy Storage

The ice energy storage measurement will consider all incremental ice energy storage (i.e., excluding chillers that do not utilize storage to shift load) as summed at the end of RY3. Project specifications will be collected through the Company's Incremental System Peak MW Reduction and NWS programs, including the 2019 Demand Management Program. If a project is installed outside of these programs, the Company will try to obtain the required information from the companies or customers involved.

Annualized avoided kg CO_2e emissions from ice energy storage are calculated as explained below. Analogous to batteries, ice energy storage reduces emissions during system peak times during the summer by avoiding peak electricity use while the ice storage system "discharges," and has lower associated grid emissions when it recharges, i.e., makes ice from water. The net beneficial emissions impact is the difference between the higher emissions avoided during the discharge time and the lower emissions during the charge time.

$$(Installs) * \left(\frac{0.55kW}{cooling\ ton}\right) * \left(\frac{tons}{install}\right) * \left[\left((Discharge\ time\ per\ day) * (110\ days\ per\ year) * \left(\frac{Peak\ kgCO_2e}{MWh}\right)\right) - \left(\frac{(Charge\ time\ \ per\ day) * (110\ days\ per\ year) * \left({Grid\ kgCO_2e}/{MWh}\right)}{90\%\ Round\ Trip\ Efficiency}\right)\right]$$

Where:

Installs	The number of ice energy storage plants installed and that can be expected to have begun operations in the Company's service territory in the rate year
0.55kW / cooling ton	Electricity associated with each ton of ice energy storage
Discharge time per day	The hours per day an ice storage plant discharges
Charge time per day	The hours per day an ice storage plant charges
Peak kg CO_2e / MWh	The emission intensity associated with peak electric demand from the EPA eGRID for the NPCC NYC/Westchester subregion

Grid kg CO_2e / MWh — The average New York City emissions factor from the most recent New York City GHG Inventory available at the time the EAM metric targets are determined

Round Trip Efficiency — How efficient an ice storage plant is at reproducing the energy it consumed during charging

Electric Heat Pump Water Heaters

The electric heat pump water heater measurement will consider all incremental electric heat pump water heater installations as summed at the end of RY3. End-of-year incremental installed units will be tracked from the Company's energy efficiency incentive programs and NYSERDA-provided data.

Annualized net avoided kg CO_2e emissions from electric heat pump water heaters will be calculated by determining the avoided emissions from removing a natural gas fired hot water tank while accounting for the lower emissions associated with the electric consumption of the heat pump water heater. For the purposes of the Emissions Reduction EAM, the Collaborative has developed this single framework for calculating avoided GHG emissions associated with electric heat pump water heaters, which can be expected to be generally representative of electric heat pump water heater installations in Company territory.

$$(Electric\ Heat\ Pump\ Water\ Heater\ Units) * \left[\left(Avoided\ Dth * \frac{kgCO2e}{Dth_{CH4}}\right) - (MWh\ Heating\ Consumed) * \left({}^{Grid\ kgCO_2e}/_{MWh}\right)\right]$$

Where:

Electric Heat Pump Water Heater Units — The number of electric heat pump water heater units installed and that can be expected to have begun operations in the Company's service territory in RY3

Avoided Dth — The reduction in natural gas consumption in Dth from removing a natural gas fired water heater

kg CO_2e / Dth_{CH4} — The emission intensity of burning natural gas

MWh Heating Consumed — The increase in electric consumption for water heating due to replacing a natural gas water heater with an electric heat pump water heater

Grid kg CO_2e / MWh — The average New York City emissions factor from the most recent New York City GHG Inventory available at the time the EAM metric targets are determined

Wind Energy

The wind energy measurement will initially consider all incremental distributed wind energy installations interconnected to the Company's electric distribution system as summed at the end of RY3. End-of-year incremental installed capacity will be tracked from interconnected wind energy projects submitted through the NYS SIR process. The Company will count those wind energy installations toward the Emissions Reduction EAM metric when the Company submits a final interconnection letter to the customer noting that all interconnection work has been completed, which enables the wind energy installation to begin operating as part of the overall Con Edison electric distribution system.

The methodology for wind energy avoided GHG calculation is the same as the rooftop solar PV calculation except for a higher capacity factor. Annualized avoided kg CO_2e emissions consumed by wind energy[33] installations will be calculated as:

$$(MW\ wind\ energy) * (15\%\ Capacity\ factor) * (Annual\ Hours) * \left(\frac{Grid\ kg\ CO_2e}{MWh}\right)$$

Where:

MW wind energy	The MWs of distributed wind energy installed and that can be expected to have begun operations in the Company's service territory in the rate year
Annual Hours	8,760
Grid kg CO_2e / MWh	The average New York City emissions factor from the most recent New York City GHG Inventory available at the time the EAM metric targets are determined

Voluntary Renewable Energy Certificates

The Collaborative parties agree that the VREC measurement will consider all in-state VREC activity in the Company territory in RY3. Each in-state VREC represents one MWh of renewable energy produced in New York State and acquired in or on behalf of any customer or entity in the Company territory, and incremental to any mandatory obligation under the Clean Energy Standard.[34] Each VREC will be converted to an annualized avoided kg CO_2e using the latest eGRID statewide New York kg CO_2e / MWh figure available at the time the EAM metric targets are determined.

During the emissions collaborative, some parties expressed a preference for VREC resources in or near the Company's service territory. The parties agree that location is an important consideration, but local REC supplies are limited and the local REC market is generally illiquid. Confining this measurement to

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[33]http://www.nyiso.com/public/webdocs/media_room/publications_presentations/Power_Trends/Power_Trends/2017_Power_Trends.pdf

[34] Case 15-E-0302, *Proceeding on Motion of the Commission to Implement a Large-Scale Renewable Program and a Clean Energy Standard*, Order Adopting a Clean Energy Standard (issued August 1, 2017).

only local resources at the current time would reduce the potential positive impact of this aspect of the Emissions Reduction EAM metric both regionally and locally over the longer term. But to the extent possible, the parties agree that the Company should track VREC resource origin locality using the New York Generation Attribute Tracking System ("NYGATS") to inform service territory proximity, and determine if and when locational granularity should inform the VRECs emissions calculations.

Also during the emissions collaborative, some parties expressed concerns regarding who would bear costs related to VREC purchases, but the parties agree that VRECs, as developed for the purposes of this EAM, would refer to VREC acquisitions made directly by or on behalf of willing customers; i.e., customers who have voluntarily decided to make such purchases or have another entity make purchases on their behalf. Further, to additionally maintain transparency, the Company will identify and explain activity related to VRECs that contribute to the EAM, in its annual EAM filing. Additionally, to the extent the Company is directly involved in any VREC purchases on behalf of willing customers, the parties agree that the pricing related to such VREC purchases should be transparent to the customer.

iii. Broad Approach Discussion

The second design option discussed in the emissions collaborative is a broad approach initially based on the annually-published New York City GHG Inventory ("Inventory"). The Collaborative parties agree that the broad approach has merit by its focus on more holistic, territory-wide emissions reductions. However, the broad approach was not selected as the EAM metric due to the complexities of developing a territory-wide emissions inventory and establishing targets that can meaningfully measure achievements isolated from other macro-effects impacting emissions.

iv. Broad Approach Measurement

An Inventory-based scorecard metric would measure actual reductions in net kg CO_2e emissions associated with electric, natural gas, and petroleum energy consumption by customers in Con Edison's service territory. The broad nature of this design is meant to capture holistic emissions impacts beyond emissions benefits of specific technologies alone. This more holistic approach can support broad territory-wide efforts to facilitate reduction of emissions over time, including a broad portfolio of mitigation measures including energy efficiency, distributed generation, beneficial electrification, and distribution of less carbon-intensive electricity, without limiting focus to a few technology-specific categories of emissions mitigation efforts.

For such a broad-based metric to be appropriate, it would need to be normalized for exogenous factors such as economic growth, employment, natural catastrophic incidents such as hurricane related disruptions, retirement or introduction of major new generating facilities, and demographic trends. This would generally require a highly sophisticated modeling methodology that goes beyond the already complex inventory development to identify causation factors to a degree of precision and accuracy that has hitherto not been available. Another significant challenge to the broad approach measurement is the lag associated with the complex process of inventory development and publication. This lag prevents timely analysis of any territory-wide efforts even if models were to become available. Another concern is that, to the knowledge of the parties, there is not a regularly updated inventory or other similar data source for GHG emissions in Westchester County.[35]

Because of the above issues the broad approach measurement will, at this time, be tracked as a scorecard metric for RY2 and RY3, and will include the Inventory's stationary energy and transportation values.[36] The parties agreed that this design has significant merit but requires further investigation for potential use in the future, and should account for net avoided emissions from beneficial electrification activities in addition to efforts resulting in direct CO_2e emission reductions, based on applicable emission factors.

C. Electric Energy Intensity Reduction

i. Discussion

The Electric Energy Intensity Reduction outcome-based EAM is intended to incentivize efforts that will result in a decrease in electric energy intensity or electric energy consumption beyond recent trajectories. To the extent that the decline in electric energy intensity or electric energy consumption improves beyond the trend in electric energy intensity or electric energy consumption that has taken place as further described below, the Company will earn the Electric Energy Intensity Reduction outcome-based EAM.[37] To this end, the supporting parties propose that Electric Energy Intensity Reduction performance targets are set such that the levels of residential MWh per customer ("RES"),[38] commercial MWh per private employee ("COM"),[39] and Multifamily and Public ("MFP")[40] gigawatt-hour ("GWh") sales, on a weather-normalized basis at the end of RY3, will fall below their respective declining intensity or GWh trajectory.[41]

ii. Metric Components

RES and COM

1. Numerator

[35] Westchester County did not participate in the collaborative meetings for this proposal.

[36] The Inventory is published up to twelve months after the end of each calendar year. The Company will report in its March 31 EAM filings the most recent Inventory's stationary energy and transportation data, including data from each year starting in 2014, which is the first year the Inventory adopted its currently used calculation methodology.

[37] Some parties are concerned that linking the earning of an EAM, for this and other proposed EAMs, for activities that are wholly or largely removed from the behavior and control of the Company is contrary to the interest of ratepayers as well as of the Company.

[38] For RES, electric energy consumption used in the numerator of the metric refers to energy sales attributable to customers belonging to Service Classification 1 ("SC1").

[39] For COM, electric energy consumption used in the numerator of the metric refers to energy sales attributable to customers belonging to Service Classification 2 ("SC2") and Service Classification 9 ("SC9").

[40] For MFP, total electric energy consumption in the calculation of the metric refers to electric energy sales attributable to Service Classification 8 ("SC8"), Service Classification 12 ("SC12") master metered multi-family buildings, and public facility loads, excluding subway traction.

[41] The MFP metric differs from the residential and commercial electric energy intensity reduction metrics, as it is based on total electric energy consumption and not an intensity "ratio."

a. The electricity sales figures in the numerators for RES and COM metrics will be the 12-month rolling weather normalized monthly electricity sales. The 12-month rolling electricity sales will be adjusted ex-post for incremental RY1, RY2, and RY3 beneficial electrification usage, prorated by month of adoption.[42]
b. Prior to normalization, electricity sales will be adjusted for identified incremental beneficial electrification usage, except for heat pumps from RY1 and RY2.[43] The incremental beneficial electrification usage, as included in the DER Utilization metric, will be attributed to an appropriate Service Classification. Attribution to Service Classification will be based on actual account-level participation. The 12-month rolling commercial electricity sales will be adjusted for any identified incremental commercial beneficial electrification usage and the 12-month rolling residential electricity sales will be adjusted for any identified incremental residential beneficial electrification usage. Adjustments of the battery storage charging beneficial electrification use will only be the efficiency loss (i.e., charging MWh less discharging MWh assuming 83 percent roundtrip efficiency).

2. Denominator
    a. The denominator of the RES Electric Energy Intensity Reduction metric will be calculated using the average monthly number of active SC1 residential customer accounts in each monthly measurement period.
    b. The denominator of the COM Electric Energy Intensity Reduction metric will be average monthly total private employment for the six counties in Con Edison's service territory, based on Monthly Current Employment Statistics ("MCES"),[44] as defined by the US Bureau of Labor Statistics.

MFP

The GWh electricity sales figures for the MFP metric will be the 12-month rolling weather normalized monthly electricity sales. The 12-month rolling electricity sales will be adjusted ex-post for incremental (new in RY1, RY2, and RY3) beneficial electrification usage, prorated by month of adoption. Prior to normalization, electricity sales will be adjusted for identified incremental beneficial electrification usage, except for heat pumps in RY1 and RY2. The incremental beneficial electrification usage, as included in the DER Utilization metric, will be attributed to an appropriate Service Classification. Attribution to Service Classification will be based on actual account-level participation. The 12-month rolling SC8, SC12, and Public electricity sales will be adjusted for any identified incremental beneficial electrification usage. Adjustments of the battery storage charging beneficial use will only be the efficiency loss (i.e. charging MWh less discharging MWh assuming 83% roundtrip efficiency). The MFP metric does not have a denominator.

[42] For RY3, the electric energy intensity reduction metrics could adjust for incremental beneficial electrification above and beyond the RY1 and RY2 achievements.

[43] Heat pump adoption for electric energy efficiency may result in a net decrease in electric consumption. Heat pump adoption for fuel-switching is a beneficial electrification. The Collaborative is incorporating for RY3 methods to adjust the energy intensity metrics for heat pump beneficial electrification.

[44] The COM metric will use the most recent private employment figures available for the six counties through the MCES at the time of development of the annual report summarizing the Company's EAM achievements for RY3 in March 2020.

The Collaborative parties agree that improvements to the MFP metric should be investigated for future rate years, including but not limited to selecting a denominator, separating or removing certain service classes due to outlier impacts, or other ways to reduce volatility and increase data quality.

Normalization

Electricity sales were normalized for weather by Service Classification using models developed by Staff. The dependent variables are electricity sales per customer for the RES model, electricity sales per private employee for the COM model, and electricity sales for the MFP model, each in natural logarithm transformation. The independent variables in the models are billing cycle monthly Heating Degree Days ("HDD") and Cooling Degree Days ("CDD"), defined the same as used for the electricity sales forecast in this rate case. All models are adjusted for billing days and include a linear time trend dummy variable representing the impact of energy efficiency programs. The models were estimated by the least square regression method using historical data from January 2010 through December 2015. Normal weather is defined as a 10-year average CDD and HDD for 2006-2015.

The weather coefficients and mathematical representation of the weather normalization models are included in Appendix A. These coefficients and 10-year average based normal weather figures will remain fixed for the calculation of weather normalized sales used to determine the Electric Energy Intensity Reduction metric values at the end of RY3 (i.e., after December 31, 2019).

iii. Measurement

Target

The weather normalized 12-month rolling December 2019 target for the RES Electric Energy Intensity Reduction kWh per customer metric is set at 4,513 minimum, 4,474 target, and 4,434 maximum.

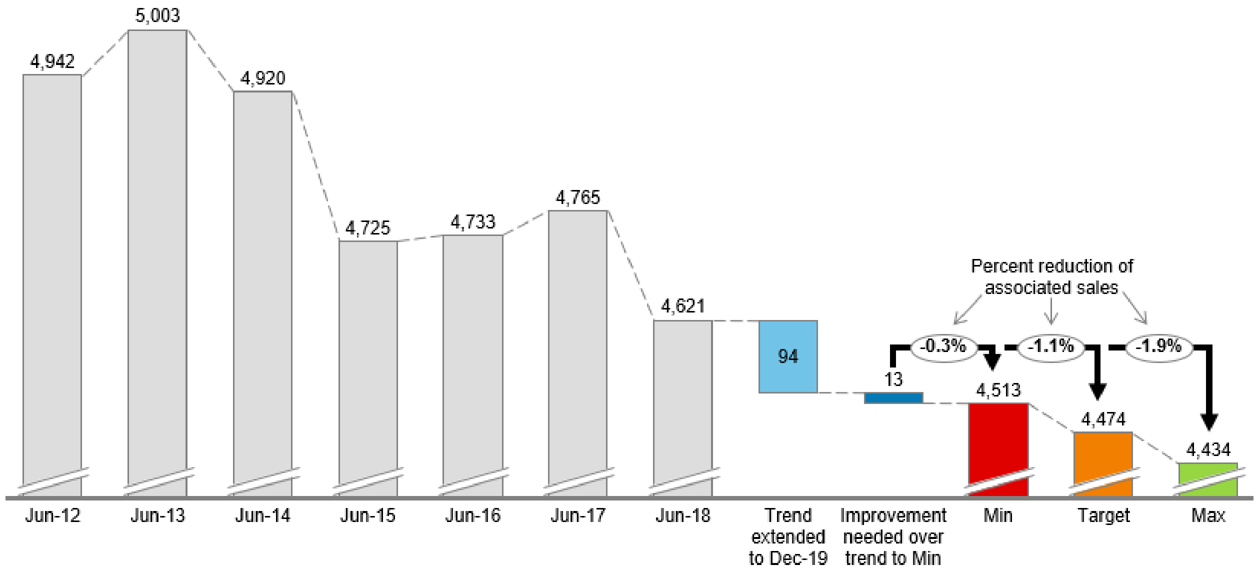
The weather normalized 12-month rolling December 2019 target for the COM Electric Energy Intensity Reduction kWh per employee metric is set at 6,583 minimum, 6,536 target, and 6,489 maximum.

The weather normalized 12-month rolling December 2019 target for the MFP Electric Energy Intensity Reduction GWh metric is set at 9,466 minimum, 9,383 target, and 9,300 maximum.

These targets are intended to ensure improvement on projected December 2019 12-month weather adjusted rolling 4,526 kWh per residential (SC1) customer, 6,599 kWh per private sector employee (SC2 plus SC9), and 9,494 GWh for MFP as of December 2019, which would occur if the recent intensity improvements continue at the same rate from the last observed point(s).

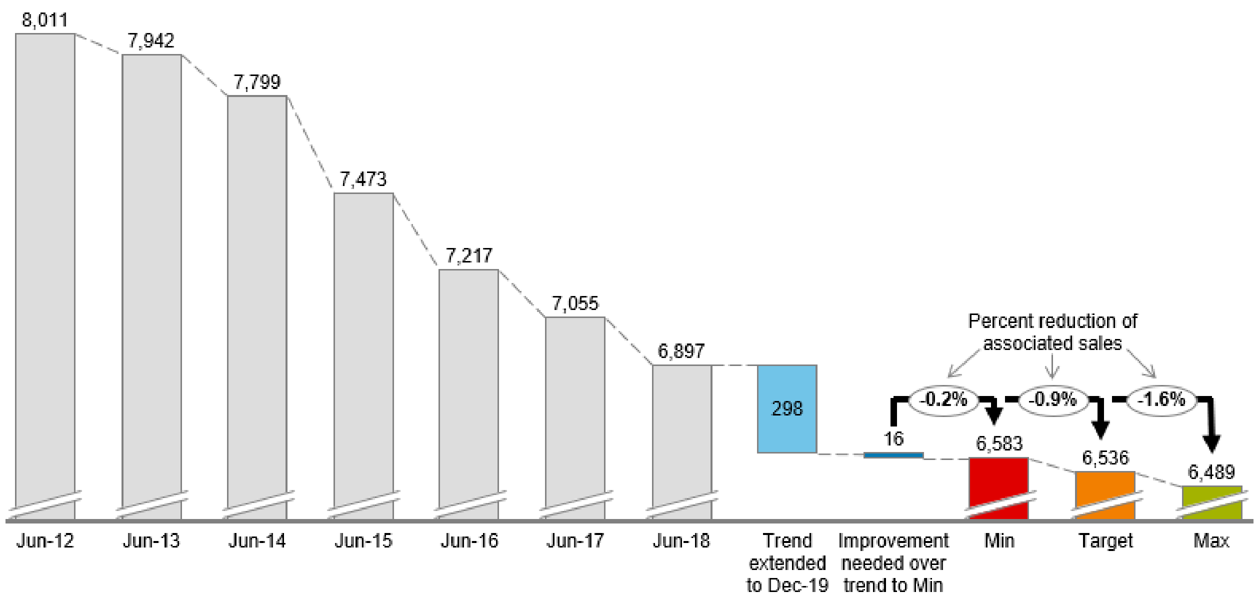
Residential Electric Energy Intensity Reduction

Annual kWh per SC1 customer



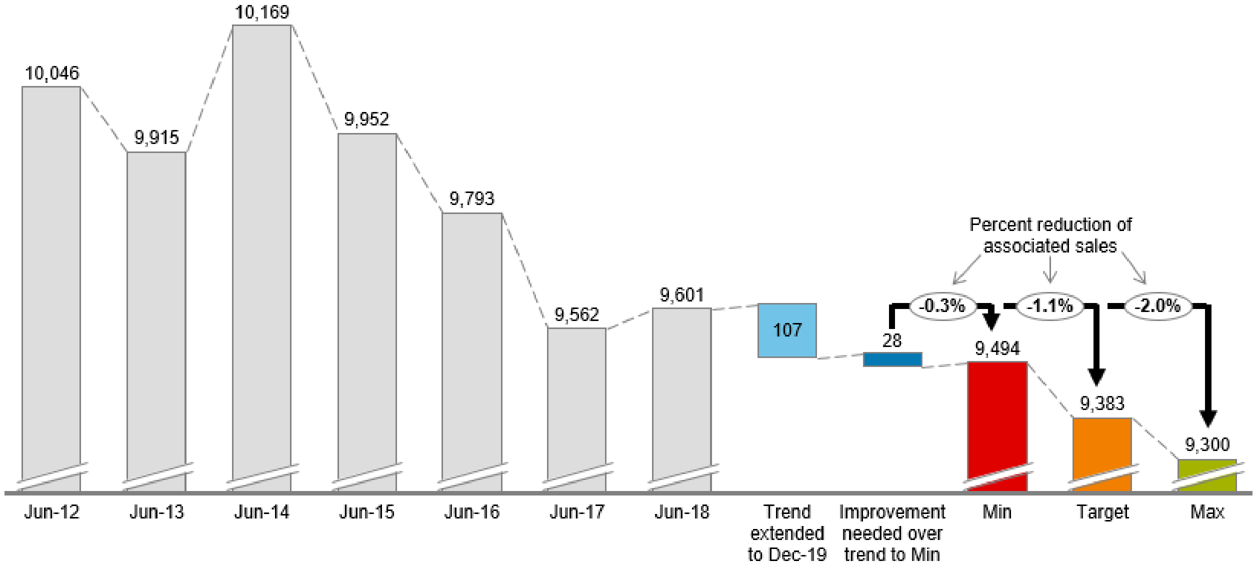
Commercial Electric Energy Intensity Reduction

Annual kWh per private employee



MFP Electric Energy Intensity

Annual GWh



The target levels were determined as follows:

A simple linear trend was estimated on rolling 12-month weather normalized electric energy intensity figures covering the period of December 2010 through September 2016 for RES SC1 and for the combined COM SC2 plus SC9. For MFP, the simple linear trend was estimated with data from and December 2010 through December 2016. These estimation periods reflect all the necessary actual electricity sales, customer counts, employment, and degree day information available to date. The equations for the estimated trend lines (along with coefficient estimates and standard errors) are shown in Appendix A. The estimated trend lines were shifted to continue off of the most recent 12-month rolling actuals for each metric (RES, COM, and MFP). These trend lines were extended out to December 2019 at the same slope as the historical trend and represent the recent trajectory. The Electric Energy Intensity Reduction metric targets reflect a reduction in the following amounts from the level of each shifted trend line in December 2019: the minimum level is set at 0.25 standard errors below each December 2019 shifted trend line value; the target level is set at 1.00 standard errors below each December 2019 shifted trend line value; and the maximum level is set at 1.75 standard errors below each December 2019 shifted trend line value.

4. Outcome-Based EAM Incentives

Tables 2 and 3 below represent RY3 outcome-based EAM incentive and achievement levels, respectively. The Collaborative parties agree that incentive levels for RY3 are to be allocated 50 percent to DER Utilization, 25 percent to GHG Emissions Reduction, and 25 percent to Electric Energy Intensity Reduction. The Electric Energy Intensity Reduction metric contains three metrics with incentive levels split by collective load share: COM: 56 percent, RES: 26 percent, and MFP: 18 percent.

Table 2: RY3 Incentive Levels[45]

$Million	Min	Target	Max
DER Utilization	4.173	8.345	15.295
GHG Emissions Reduction	2.086	4.173	7.648
RES Energy Intensity Reduction	0.542	1.085	1.988
COM Energy Intensity Reduction	1.168	2.337	4.283
MFP Energy Intensity Reduction	0.376	0.751	1.377
TOTAL	**8.345**	**16.69**	**30.59**

Table 3: RY3 Minimum, Target, and Maximum Achievement Levels

Metric	Min	Target	Max
DER Utilization (MWh)	124,400	136,200	154,000
GHG Emissions Reduction (Metric Tons CO_2e)	20,748	22,724	25,688
RES Electric Energy Intensity Reduction (kWh / SC 1 Customer)	4,513	4,474	4,434
COM Electric Energy Intensity Reduction (kWh / Private Employee)	6,583	6,536	6,489
MFP Electric Energy Intensity Reduction (GWh)	9,466	9,383	9,300

5. Reporting

The Order requires a compliance filing on March 31, 2018, 2019, and 2020 for reporting EAM achievements.[46] For 2018, the Company intends to file a scorecard for the GHG Emissions Reduction EAM metric that provides separate information for the targeted approach and broad approach by March 31, 2019. The Company will file the 2019 EAM achievements consistent with the EAM collaborative discussions for 2019 and any applicable Commission directives by March 31, 2020.

[45] The EAM incentives are based on a straight line linear progression from the minimum to the target and from the target to the maximum metric levels.

[46] Order, Appendix A - Joint Proposal, p. 80.

Appendix A: Energy Intensity Models

Weather Normalization Models

RES Model

LOG((S1/BDA)/N1) = -8.026883 - 0.000968*TIME + 0.001502*CDD + 0.000278*HDD

COM Models

LOG((S2/BDA)/EMP) = 3.083149 - 0.002271*TIME + 0.000720*CDD + 0.000282*HDD

LOG((S9/BDA)/EMP) = 0.485228 - 0.002094*TIME + 0.000651*CDD + 0.0000604*HDD

MFP Models

LOG((S8+S12/BDA) = 5.093813 - 0.001399*TIME + 0.001242*CDD + 0.000376*HDD

LOG((P/BDA) = 20.172470 + 0.000599*CDD + 0.0000853*HDD

Where LOG stands for natural logarithm transformation; S1, S2, S9, S8, S12, and P are sales for SCs 1, 2, 9, 8, 12, and Public; BDA is billing days indexed to January 2010; N1 is # of SC 1 customers; EMP represents total private employment for the six counties in Con Edison service area (Bronx, Kings, New York, Queens, Richmond, and Westchester); TIME is 0 for January 2010, 1 for February 2010, … with monthly increment of 1; CDD is billing cycle cooling degree days (57.5˚ F based average of dry bulb and wet bulb) and HDD is billing cycle heating degree days (65˚ F based); historical data for 2010-2015 (72 data points) are used to estimate the weather normalization models.

Linear Energy Intensity Trend Models[47]

RES Energy Intensity Trend Line

sc1_wn = 5.135284 - 0.005235 x TIME

S.E. of regression = 0.052736

COM Energy Intensity Trend Line

sc29_wn = 8.560451 - 0.016528 x TIME

S.E. of regression = 0.062522

MFP Energy Intensity Trend Line

MFP_wn = 10,276.2 - 5.92916 x TIME

S.E. of regression = 111.023

Where sc1_wn stands for the monthly 12-month rolling SC1 residential sales per customer, sc29_wn stands for the monthly 12-month rolling combined SC2 and SC9 sales per employee in Con Edison service area, and MFP_wn stands for the monthly 12-month rolling combined SC8, SC12, and public facility sales, excluding subway traction; TIME is 0 for January 2010, 1 for February 2010, etc., historical data for January 2010 - September 2016 are used to estimate the energy intensity trend models.

[47] Changes result from the revision of sales data for S1 and S9 for July 2016-June 2017, employment data for April 2015-June 2017, and cooling degree day data for June 2016, which were included to estimate the linear trend models in the 2017 Outcome-based EAM Collaborative Report.

Appendix B: Emissions Reduction EAM Calculations

Attachment "Con_Edison_Emissions_Reduction_EAM_Targeted_Technologies_Calculations_2019" contains Emissions Reduction EAM targeted approach technology calculation details, which can also be found below.

kg CO_2e Avoided per MW Rooftop Solar

Capacity Factor (rooftop) = 14.1%

Annual Hours = 8760 hours

Up Time hours = $8760\ hours * 14.1\% = 1235.16\ hours$

Capacity (MW) = 1 MW

Annual MWh per MW = $1235.16\ hours \div 1\ MW = 1235.16 \frac{MWh}{MW}$

Avoided kgCO2e/MWh = $260 \frac{kgCO2e}{MWh}$

Annual kgCO2e Avoided per MW = $1235.16 \frac{MWh}{MW} * 260 \frac{kgCO2e}{MWh} = 321{,}625 \frac{kgCO2e}{MW}$

kg CO_2e Avoided per MW Community Solar

Capacity Factor (community) = 15.5%

Annual Hours = 8760 hours

Up Time hours = $8760\ hours * 15.5\% = 1357.8\ hours$

Capacity (MW) = 1 MW

Annual MWh per MW = $1357.8\ hours \div 1\ MW = 1357.8 \frac{MWh}{MW}$

Avoided kgCO2e/MWh = $260 \frac{kgCO2e}{MWh}$

Annual kgCO2e Avoided per MW = $1235.16 \frac{MWh}{MW} * 260 \frac{kgCO2e}{MWh} = {\sim}353{,}560 \frac{kgCO2e}{MW}$

kg CO_2e Avoided per MW Battery Storage

Round Trip Efficiency = 80%

Peak Emission Intensity kg/MWh = $596 \frac{kgCO2e}{MWh}$

Total Emission Intensity kg/MWh = $260 \frac{kgCO2e}{MWh}$

kgCO2e Avoided per MWh = $\left(596 \frac{kgCO2e}{MWh} - 260 \frac{kgCO2e}{MWh}\right) \div 80\% = 271 \frac{kgCO2e}{MWh}$

Charge time (hours) = 4 hours

Discharge time (hours) = 4 hours

Days Run = 365 days per year

Capacity (MW) = 1 MW

MWh Discharge = $4\ hours * 365 \frac{times\ run}{year} * 1\ MW = 1{,}460 \frac{MWh}{year}$

Annual kgCO2e Avoided per MW = $1{,}460 \frac{MWh}{year} * 596 \frac{kgCO2e}{MWh} \div 1\ MW = 870{,}337 \frac{kgCO2e}{MW}$

MWh Charge = $1\ MW * 365 \frac{times\ run}{year} * 4\ hours \div 80\% = 1{,}825 \frac{MWh}{year}$

Annual kgCO2e produced per MW = $1{,}825\,\frac{MWh}{year} * 260\,\frac{kgCO2e}{MWh} \div 1\ MW\ =\ 475{,}215\,\frac{kgCO2e}{MW}$

Net Annual kgCO2e Avoided per MW = $870{,}337\,\frac{kgCO2e}{MW} - 475{,}215\,\frac{kgCO2e}{MW} = 395{,}122\,\frac{kgCO2e}{MW}$

kg CO_2e Avoided per MW Ice Energy Storage

Round Trip Efficiency = 90%

Peak Emission Intensity kg/MWh = $596\,\frac{kgCO2e}{MWh}$

Total Emission Intensity kg/MWh = $260\,\frac{kgCO2e}{MWh}$

kgCO2e Avoided per MWh = $\left(596\,\frac{kgCO2e}{MWh} - 260\,\frac{kgCO2e}{MWh}\right) \div 90\% = 307\,\frac{kgCO2e}{MWh}$

Charge time (hours) = 4 hours

Discharge time (hours) = 4 hours

Days Run = 110 days per year

Capacity (MW) = 1 MW

MWh Discharge = $4\ hours * 110\,\frac{times\ run}{year} * 1\ MW\ = 440\,\frac{MWh}{year}$

Annual kgCO2e Avoided per MW = $440\,\frac{MWh}{year} * 596\,\frac{kgCO2e}{MWh} \div 1\ MW\ = 262{,}293\,\frac{kgCO2e}{MW}$

MWh Charge = $1\ MW * 110\,\frac{times\ run}{year} * 4\ hours \div 90\% = 489\,\frac{MWh}{year}$

Annual kgCO2e produced per MW = $489\,\frac{MWh}{year} * 260\,\frac{kgCO2e}{MWh} \div 1\ MW\ =\ 127{,}302\,\frac{kgCO2e}{MW}$

Net Annual kgCO2e Avoided per MW = $262{,}293\,\frac{kgCO2e}{MW} - 127{,}302\,\frac{kgCO2e}{MW} = 134{,}991\,\frac{kgCO2e}{MW}$

$kgCO_2e$ Avoided per Light Duty BEV (BEV replacing gasoline internal combustion engine vehicle)

BTU per gallon of gasoline = 123,000 BTU/gallon of gasoline

1 kWh = 3,414 BTU

kWh per Gallon of gasoline = $\frac{123{,}000\ BTU}{Gallon\ (gasoline)} * \frac{1\ kWh}{3{,}414\ BTU} = 36.03\,\frac{kWh}{Gallon\ (gasoline)}$

Gallons per MWh = $\frac{1000\ kWh}{1\ MWh} * \frac{1\ gallon_{gasoline}}{36.03\ kWh} = 27.76\ \frac{Gallons\ (gasoline)}{1\ MWh}$

kgCO2e emitted per liter of gasoline = 2.425

Convert liters to gallons = $2.425\,\frac{kgCO2e}{1\ Liter} * \frac{1\ Liter}{0.264172\ gallons} = 9.18\,\frac{kgCO2e}{1\ Gallon\ (gasoline)}$

kgCO2e per MWh of energy in gasoline = $9.18\,\frac{kgCO2e}{1\ Gallon\ (gasoline)} *\ 27.76\ \frac{Gallons\ (gasoline)}{1\ MWh} = \sim 254.79\,\frac{kgCO2e}{MWh\ (gasoline)}$

Passenger vehicle efficiency (miles per gallon of gasoline) = 22 miles/gallon (gasoline)

Miles per MWh (gasoline car) = $27.76\ \frac{Gallons\ (gasoline)}{1\ MWh} * 22\,\frac{miles}{gallon} = 610.63\,\frac{miles}{MWh}$

kgCO2e/mile (gasoline car) = $254.79\,\frac{kgCO2e}{MWh}\,(gasoline)\ \div 610.63\,\frac{miles}{MWh} = \sim 0.42\,\frac{kgCO2e}{mile}$

Passenger EV efficiency (kWh/mile) = 0.34 kWh/mile

kgCO2e / mile (electric car) = $0.34\,\frac{kWh}{mile} * 260\,\frac{kgCO2e}{MWh} * \frac{1\ MWh}{1000\ kWh} = \sim 0.09\,\frac{kgCO2e}{mile_{electric\ car}}$

CO2e savings/mile (gas-electric) = $0.42\,\frac{kgCO2e}{mile_{gasoline}} - 0.09\,\frac{kgCO2e}{mile_{electric\ car}} = \sim 0.329\,\frac{kgCO2e}{mile}$

Net CO2e avoided per EV per year = $\frac{11{,}824\left(\frac{miles}{vehicle}\right)}{year} * 0.329\frac{kgCO2e}{mile} = \sim 3{,}890\frac{kgCO2e}{vehicle}\ per\ year$

kg CO_2e Avoided per Electric Bus (electric bus replacing diesel bus)

BTU per gallon of diesel = 138,490 BTU/gallon of diesel

1 kWh = 3,414 BTU

kWh per Gallon of diesel = $\frac{138{,}490\ BTU}{Gallon\ (diesel)} * \frac{1\ kWh}{3{,}414\ BTU} = 40.57\frac{kWh}{Gallon\ (diesel)}$

Gallons per MWh = $\frac{1000\ kWh}{1\ MWh} * \frac{1\ gallon_{diesel}}{40.57\ kWh} = 24.65\ \frac{Gallons\ (diesel)}{1\ MWh}$

kgCO2e emitted per liter of diesel = 2.685

Convert liters to gallons = $2.685\frac{kgCO2e}{1\ Liter} * \frac{1\ Liter}{0.264172\ gallons} = 10.16\frac{kgCO2e}{1\ Gallon\ (diesel)}$

kgCO2e per MWh of energy in diesel = $10.16\frac{kgCO2e}{1\ Gallon\ (diesel)} *\ 24.65\ \frac{Gallons\ (diesel)}{1\ MWh} =$

$\sim 250.55\frac{kgCO2e}{MWh\ (diesel)}$

Diesel bus efficiency (miles per gallon of diesel) = 2.28 miles/gallon (diesel)

Miles per MWh (diesel bus) = $24.65\ \frac{Gallons\ (diesel)}{1\ MWh} * 2.28\frac{miles}{gallon} = 56.21\frac{miles}{MWh}$

kgCO2e/mile (diesel bus) = $250.55\frac{kgCO2e}{MWh}(diesel)\ \div 56.21 = \sim 4.46\frac{kgCO2e}{mile}$

Bus EV efficiency (kWh/mile) = 3.90 kWh/mile

kgCO2e / mile (electric car) = $3.90\frac{kWh}{mile} * 260\frac{kgCO2e}{MWh} * \frac{1\ MWh}{1000\ kWh} = \sim 1.02\frac{kgCO2e}{mile_{electric\ bus}}$

CO2e savings/mile (diesel - electric) = $4.46\frac{kgCO2e}{mile_{diesel}} - 1.02\frac{kgCO2e}{mile_{electric\ bus}} = \sim 3.44\frac{kgCO2e}{mile}$

Net CO2e avoided per electric bus per year = $\frac{6836\left(\frac{miles}{vehicle}\right)}{year} * 3.44\frac{kgCO2e}{mile} = \sim 23{,}531\frac{kgCO2e}{vehicle}\ per\ year$

kg CO_2e Avoided per MW Wind

Capacity Factor (rooftop) = 15% (Distributed Wind Capacity Factor for 0 kW to 100 kW wind turbines)

Annual Hours = 8760 hours

Up Time hours = $8760\ hours * 15\% = 1314\ hours$

Capacity (MW) = 1 MW

Annual MWh per MW = $1314\ hours \div 1\ MW\ = 1314\frac{MWh}{MW}$

Avoided kgCO2e/MWh = $260\frac{kgCO2e}{MWh}$

Annual kgCO2e Avoided per MW = $1314 * 260\frac{kgCO2e}{MWh} = \sim 342{,}155\frac{kgCO2e}{MW}$

Beneficial Electrification for ASHP Heating (replacing gas/oil furnace with ASHP):

Tons/unit = 1.07 (Weighted Average of Con Ed 2018 portfolio)

kBTU/hr*unit = 12.84 ; 1 ton = 12,000 BTU hr^{-1}; $\left(\frac{1.07\ tons}{unit} * \frac{12000\ BTU}{1\ ton*hr}\right)/1000$

HSPF_ee = 9.2 $BTU\ Whr^{-1}$ (Assume high efficiency model; COP 2.7)

ELFH = 526 hours (TRM Input, Appendix G: Assume high-rise pre 1979 NYC) kWh Consumed/unit heating = $\frac{12.84\ kBTU\ hr^{-1}}{0.0092\ kBTU\ Whr^{-1}} = 1395\ Watts$

$1395\ W * 526\ hours = 733{,}770\ Wh\ \left(\frac{1\ kWh}{1000\ Wh}\right) = 734\ kWh$ ← used for DER Utilization

$1\ MWh = 3.41214\ MMBTU$

$\frac{1\ MWh}{3.41214\ MMBTU} = \frac{1\ kWh}{3412.14\ BTU}$

BTU consumed $= 3412.14 \frac{BTU}{1\ kWh} * 734\ kWh = 2{,}504{,}896.48\ BTU$

BTU required for heating $= 12.84 \frac{kBTU}{hour * unit} * \frac{1000\ BTU}{1\ kBTU} * 526\ hours = 6{,}753{,}840 \frac{BTU}{unit}$

Assumed Furnace efficiency = 80%

BTU Consumed by equivalent furnace $= \frac{6{,}753{,}840\ BTU}{80\%} = 8{,}442{,}300 \frac{BTU}{unit}$

kWh consumed by equivalent furnace $= 8{,}442{,}300 \frac{BTU}{unit} * \left(\frac{1\ kWh}{3412.14\ BTU}\right) = 2474 \frac{kWh}{unit}$

kWh saved for ASHP Efficient Cooling (replacing existing Room AC with ASHP):

$SEER_{base}$ = 9.8 BTU Wh^{-1} (TRM Input: Normal Replacement)

$SEER_{ee}$ = 18 BTU Wh^{-1} (TRM Input: High Efficiency Model)

$EFLH_{cool}$ = 793 hours (TRM Input, Appendix G: Assuming high-rise pre-1979 NYC)

Annual kWh saved/ unit replaced:

$$\Delta kWh_{cooling\ mode} = units * \frac{tons}{unit} * \left(\frac{12}{SEER_{baseline}} - \frac{12}{SEER_{ee}}\right) * EFLH_{cooling}$$

$$= 1\ unit * 1.07 \frac{tons}{unit} * \left(\frac{12\ kBTU\ (h * ton)^{-1}}{9.8\ BTU\ Wh^{-1}} - \frac{12\ kBTU\ (h * ton)^{-1}}{18\ BTU\ Wh^{-1}}\right) * 793\ hours$$

$$= 473\ kWh\ per\ unit$$

$$\Delta kW_{cooling\ mode} = units * \frac{tons}{unit} * \left(\frac{12}{EER_{baseline}} - \frac{12}{EER_{ee}}\right) * CF$$

$$= 1\ unit * 1.07 \frac{tons}{unit} * \left(\frac{12\ kBTU\ (h * ton)^{-1}}{9.8\ BTU\ Whr^{-1}} - \frac{12\ kBTU\ (h * ton)^{-1}}{12.8\ BTU\ Whr^{-1}}\right) * 0.8\ CF$$

$$= 0.246\ kW\ per\ unit$$

kWh saved for ASHP Efficient Cooling (replacing existing Central AC with ASHP):

$SEER_{base}$ = 13 BTU Wh^{-1} (TRM Input: Normal Replacement)

$SEER_{ee}$ = 18 BTU Wh^{-1} (TRM Input: High Efficiency Model)

$EFLH_{cool}$ = 793 hours (TRM Input, Appendix G: Assuming high-rise pre-1979 NYC)

Annual kWh saved/ unit replaced:

$$\Delta kWh_{cooling\ mode} = units * \frac{tons}{unit} * \left(\frac{12}{SEER_{baseline}} - \frac{12}{SEER_{ee}}\right) * EFLH_{cooling}$$

$$= 1\ unit * 1.07 \frac{tons}{unit} * \left(\frac{12\ kBTU\ (h * ton)^{-1}}{13\ BTU\ Wh^{-1}} - \frac{12\ kBTU\ (h * ton)^{-1}}{18\ BTU\ Wh^{-1}}\right) * 793\ hours$$

$$= 218\ kWh\ per\ unit$$

$$\Delta kW_{cooling\ mode} = units * \frac{tons}{unit} * \left(\frac{12}{EER_{baseline}} - \frac{12}{EER_{ee}}\right) * CF$$

$$= 1\,unit * 1.07\frac{tons}{unit} * \left(\frac{12\ kBTU\ (h * ton)^{-1}}{11.09\ BTU\ Whr^{-1}} - \frac{12\ kBTU\ (h * ton)^{-1}}{12.8\ BTU\ Whr^{-1}}\right) * 0.8\ CF$$
$$= 0.124\ kW\ per\ unit$$

Assume 20% CAC = 0.124 kW * 0.2 = 0.025 kW
Assume 80% RAC = 0.246 kW * 0.8 = 0.197 kW
Assume 20% CAC = 217.57 kWh * 0.2 = 43.51 kWh
Assume 80% RAC = 473.32 kWh * 0.8 = 378.65 kWh
378.7 kWh + 43.5 kWh = ~422.2 kWh saved/unit replaced (RAC & CAC) ← used for DER Utilization

0.197 kW + 0.025 kW = ~0.221 kW/unit (RAC & CAC)

kgCO₂e Avoided per Unit ASHP (cooling and heating):

Units per MW $= \frac{1000\ kW}{0.221\ kW} = 4519\ units\ per\ MW$

Cooling MWh saved per MW $= 4519\ units * 422.2\ kWh\frac{1\ MWh}{1000\ kWh} = 1908\ MWh\ saved\ per\ MW$

kg CO2e Avoided for cooling per MW $= 1908\frac{MWh}{MW} * 260.3916\frac{kgCO2e}{MWh} = 496{,}790\ kgCO2e\ per\ MW$

Heating MWh consumed per MW:

$$= 4519\ units\ per\ MW * 734\ kWh * \frac{1\ MWh}{1000\ kWh} = 3317.6\ MWh\ per\ MW$$

kg CO2e produced for heating per MW:

$$= 3317.6\frac{MWh}{MW} * 260.3916\frac{kgCO2e}{MWh} = 863{,}874\ kgCO2e\ per\ MW$$

Heating MWh avoided (furnace) per MW:

$$= 4519\frac{units}{MW} * 2474.2\frac{kWh}{unit} * \frac{1\ MWh}{1000\ kWh} = 11{,}181.36\ MWh\ per\ MW$$

kg CO2e avoided for heating (furnace) per MW:

$$= 11{,}181.36\frac{MWh}{MW} * \left[\left(127.98\frac{kgCO2e}{MWh_{\ gas\ heating}} * 0.7\right) + \left(213.1\frac{kgCO2e}{MWh_{\ oil\ heating}} * 0.3\right)\right]$$
$$= 1{,}716{,}513\ kgCO2e\ per\ MW$$

Net kgCO2e avoided for heating per MW:

$$= 1{,}716{,}513\frac{kgCO2e}{MW} - 863{,}874\frac{kgCO2e}{MW} = 852{,}639\frac{kgCO2e}{MW}$$

Total kgCO2e avoided per MW:

$$= 852{,}639\frac{kgCO2e}{MW} + 496{,}790\frac{kgCO2e}{MW} = 1{,}349{,}429\frac{kgCO2e}{MW}$$

Total kgCO2e avoided per unit:

$$= 1{,}349{,}429\frac{kgCO2e}{MW} \div 4519\frac{units}{MW} = 298.6\frac{kgCO2e}{unit}$$

Beneficial Electrification for GSHP Heating (replacing gas/oil furnace with GSHP):

Tons/unit = 3.1 (Assume heat pump replaces similarly sized room AC(S)
kBTU/hr*unit = 12 * 3.1 tons/unit (Assumption) = 37.2 tons/unit

HSPF_ee = $\left(\frac{4.2+3.0}{2}\right) * \frac{3412.14\ BTU}{1\ kWh} * \frac{1\ kW}{1000\ W} = 12.28\ BTU\ Whr^{-1}$

ELFH = 786 hours (TRM Input, Appendix G: Assume NYC single family detached heating)

kWh Consumed/unit heating = $\frac{37.2\ kBTU\ hr^{-1}}{0.01228\ kBTU\ Whr^{-1}} = 3{,}029\ Watts$

$3029\ W * 786\ hours = 2{,}381{,}042\ Wh\ \left(\frac{1\ kWh}{1000\ Wh}\right) = \sim 2{,}380\ kWh$ ← used for DER Utilization

$1\ MWh = 3.41214\ MMBTU$

$\frac{1\ MWh}{3.41214\ MMBTU} = \frac{1\ kWh}{3412.14\ BTU}$

BTU consumed $= 3412.14 \frac{BTU}{1\ kWh} * 2380\ kWh = 8{,}122{,}000\ BTU$

BTU required for heating $= 37.2 \frac{kBTU}{hour * unit} * \frac{1000\ BTU}{1\ kBTU} * 786\ hours = 29{,}239{,}200 \frac{BTU}{unit}$

Assumed Furnace efficiency = 80%

BTU Consumed by equivalent furnace $= \frac{29{,}239{,}200\ BTU}{80\%} = 36{,}549{,}000 \frac{BTU}{unit}$

kWh consumed by equivalent furnace $= 36{,}549{,}000 \frac{BTU}{unit} * \left(\frac{1\ kWh}{3412.14\ BTU}\right) = \sim 10{,}711.46 \frac{kWh}{unit}$

Ground Source Heat Pump Cooling Analysis (replacing existing Room AC with GSHP):

$SEER_{base}$ = 9.8 BTU Wh^{-1} (TRM Input: Based on the kBTU / Range and assume louvered sides)

$SEER_{ee}$ = 19.75 BTU Wh^{-1}

$EFLH_{cool}$ = 649 hours (TRM Input, Assume same (i.e. room AC used to cool more than just room and therefore runs more hours than assumed in TRM))

Annual kWh saved/ unit replaced:

$$\Delta kWh_{cooling\ mode} = units * \frac{tons}{unit} * \left(\frac{12}{SEER_{baseline}} - \frac{12}{SEER_{ee}}\right) * EFLH_{cooling}$$

$$= 1\ unit * 3.1 \frac{tons}{unit} * \left(\frac{12\ kBTU\ (h * ton)^{-1}}{9.8\ BTU\ Wh^{-1}} - \frac{12\ kBTU\ (h * ton)^{-1}}{19.75\ BTU\ Wh^{-1}}\right) * 649\ hours$$

$$= \sim \mathbf{1{,}241.13\ kWh\ per\ unit}$$

$$\Delta kW_{cooling\ mode} = units * \frac{tons}{unit} * \left(\frac{12}{EER_{baseline}} - \frac{12}{EER_{ee}}\right) * CF$$

$$= 1\ unit * 3.1 \frac{tons}{unit} * \left(\frac{12\ kBTU\ (h * ton)^{-1}}{9.8\ BTU\ Whr^{-1}} - \frac{12\ kBTU\ (h * ton)^{-1}}{17.1\ BTU\ Whr^{-1}}\right) * 0.69\ CF$$

$$= \sim \mathbf{1.12\ kW\ per\ unit}$$

Ground Source Heat Pump Cooling Analysis (replacing existing Central AC with GSHP):

$SEER_{base}$ = 13 BTU Wh^{-1} (TRM Input: Normal Replacement)

$SEER_{ee}$ = 18 BTU Wh^{-1} (TRM Input: High Efficiency Model)

$EFLH_{cool}$ = 649 hours (TRM Input, Appendix G: Assuming high-rise pre-1979 NYC)

Annual kWh saved/ unit replaced:

$$\Delta kWh_{cooling\ mode} = units * \frac{tons}{unit} * \left(\frac{12}{SEER_{baseline}} - \frac{12}{SEER_{ee}}\right) * EFLH_{cooling}$$

$$= 1\ unit * 3.1 \frac{tons}{unit} * \left(\frac{12\ kBTU\ (h * ton)^{-1}}{13\ BTU\ Wh^{-1}} - \frac{12\ kBTU\ (h * ton)^{-1}}{18\ BTU\ Wh^{-1}} \right) * 649\ hours$$

$$= \sim\mathbf{515.87\ kWh\ per\ unit}$$

$$\Delta kW_{cooling\ mode} = units * \frac{tons}{unit} * \left(\frac{12}{EER_{baseline}} - \frac{12}{EER_{ee}} \right) * CF$$

$$= 1\ unit * 3.1 \frac{tons}{unit} * \left(\frac{12\ kBTU\ (h * ton)^{-1}}{11.09\ BTU\ Whr^{-1}} - \frac{12\ kBTU\ (h * ton)^{-1}}{17.1\ BTU\ Whr^{-1}} \right) * 0.8\ CF$$

$$= \sim\mathbf{0.943\ kW\ per\ unit}$$

Assume 20% CAC = 0.943 kW * 0.2 = 0.18863 kW
Assume 80% RAC = 0.246 kW * 0.8 = 0.8945 kW
Assume 20% CAC = 515.87 kWh * 0.2 = 103.174 kWh
Assume 80% RAC = 1241.13 kWh * 0.8 = 992.9 kWh

103.174 kWh + 992.9 kWh = ~1,096.08 kWh saved/unit replaced (RAC & CAC) ← used for DER Utilization

0.18863 kW + 0.8945 kW = ~1.083 kW/unit (RAC & CAC)

$kgCO_2e$ Avoided per Unit GSHP (cooling and heating):

Units per MW $= \frac{1000\ kW}{1.083\ kW} = 923\ units\ per\ MW$

Cooling MWh saved per MW $= 923\ units * 1100\ kWh \frac{1\ MWh}{1000\ kWh} = \sim 1{,}012\ MWh\ saved\ per\ MW$

kg CO2e Avoided for cooling per MW $= 1012 \frac{MWh}{MW} * 260.3916 \frac{kgCO2e}{MWh} = 263{,}504\ kgCO2e\ per\ MW$

Heating MWh consumed per MW:

$$= 923\ units\ per\ MW * 2380\ kWh * \frac{1\ MWh}{1000\ kWh} = \sim 2{,}197.63\ MWh\ per\ MW$$

kg CO2e produced for heating per MW:

$$= 2197.63 \frac{MWh}{MW} * 260.3916 \frac{kgCO2e}{MWh} = 572{,}243\ kgCO2e\ per\ MW$$

Heating MWh avoided (furnace) per MW:

$$= 923 \frac{units}{MW} * 10{,}711.46 \frac{kWh}{unit} * \frac{1\ MWh}{1000\ kWh} = \sim 9{,}889.32\ MWh\ per\ MW$$

kg CO2e avoided for heating (furnace) per MW:

$$= 9{,}889.32 \frac{MWh}{MW} * \left[\left(127.98 \frac{kgCO2e}{MWh_{gas\ heating}} * 0.7 \right) + \left(213.1 \frac{kgCO2e}{MWh_{oil\ heating}} * 0.3 \right) \right]$$

$$= 1{,}518{,}165\ kgCO2e\ per\ MW$$

Net kgCO2e avoided for heating per MW:

$$= 1{,}518{,}165 \frac{kgCO2e}{MW} - 572{,}243 \frac{kgCO2e}{MW} = 945{,}921 \frac{kgCO2e}{MW}$$

Total kgCO2e avoided per MW:

$$= 945{,}921 \frac{kgCO2e}{MW} + 263{,}504 \frac{kgCO2e}{MW} = 1{,}209{,}425 \frac{kgCO2e}{MW}$$

Total kgCO2e avoided per unit:

$$= 1{,}209{,}425 \frac{kgCO2e}{MW} \div 923 \frac{units}{MW} = \sim 1{,}309.97 \frac{kgCO2e}{unit}$$

$kgCO_2e$ Avoided per Unit Electric Hot Water Heater:

Natural Gas kgCO2/MMBtu = $53.06\frac{kgCO2e}{MMBTU}$

Kg to US ton conversion: 1 ton = 907.185 kg

Convert to Tons/MMBtu = $53.06\frac{kgCO2e}{MMBTU} * \left(\frac{1\ ton}{907.185\ kg}\right) = 0.058\frac{tons}{MMBTU}$

Gas Fired	Current Standard Efficiency
40 Gallon	59%
65 Gallon	55%

Average of Heating System Efficiency = $(59\% + 55\%) \div 2 = 57\%$

Tons per MMBtu Output = $0.058\frac{tons}{MMBTU} \div 57\% = 0.10\frac{Tons}{MMBTU}$

kgCO2e / MMBtu = $0.10\frac{Tons}{MMBTU} * 907.185\frac{kg}{1\ ton} = \sim 92.31\frac{kgCO2e}{MMBTU}$

kgCO2e / MWh = $92.31\frac{kgCO2e}{MMBTU} * 3.412\frac{MMBTU}{MWh} = \sim 314.97\frac{kgCO2e}{MWh}$

Electric (Heat Pump Water Heater)

Electric (Heat Pump) = $260\frac{kgCO2e}{MWh} \div 3.412\frac{MMBTU}{MWh} = \sim 76.31\frac{kgCO2e}{MMBTU}$

Convert to Tons/MMBtu = $76.31\frac{kgCO2e}{MMBTU} * \left(\frac{1\ ton}{907.185\ kg}\right) = \sim 0.084\frac{tons}{MMBTU}$

New Standard for 50 Gallon Electric Hot Water Heaters = 210% efficiency (2.1 COP)

Tons per MMBtu Output = $0.084\frac{tons}{MMBTU} \div 210\% = \sim 0.04\frac{Tons}{MMBTU}$

kgCO2e / MMBtu = $0.04\frac{Tons}{MMBTU} * 907.185\frac{kg}{1\ ton} = \sim 36.34\frac{kgCO2e}{MMBTU}$

kgCO2e / MWh = $36.34\frac{kgCO2e}{MMBTU} * 3.412\frac{MMBTU}{MWh} = \sim 124\frac{kgCO2e}{MWh}$

kgCO2e Avoided / MWh = $314.97\frac{kgCO2e}{MWh} - 124\frac{kgCO2e}{MWh} = \sim 191\frac{kgCO2e}{MWh}$

kg CO_2e avoided per Unit Electric Hot Water Heater

kW / Hot Water Heater (Heat Pump) = $0.46\frac{kW}{unit}$

Units / MW = $\frac{1000\ kW}{1\ MW} * \frac{1\ unit}{0.46\ kW} = \sim 2{,}174\frac{units}{MW}$

kWh / unit (assumption) = $384\frac{kWh}{unit}$

MWh consumed / MW = $\left(384\frac{kWh}{unit} * \frac{1\,MWh}{1000\,kWh}\right) * 2{,}174\frac{units}{MW} = {\sim}835\frac{MWh}{MW}$

Annual kg CO2e avoided / MW = $835\frac{MWh}{MW} * 191\ \frac{kgCO2e}{MWh} = 159{,}425.80\frac{kgCO2e}{MW}$

Annual kg CO2e avoided / unit = $159{,}425.80\frac{kgCO2e}{MW} * \frac{1\,MW}{2174\,units} = {\sim}73.34\frac{kgCO2e}{unit}$